Lingcod (*Ophiodon elongatus*) Egg Mass Density SCUBA Survey in the Strait of Georgia, January 15 – March 13, 2002

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LINGCOD (*Ophiodon elongatus*) EGG MASS DENSITY SCUBA SURVEY IN THE STRAIT OF GEORGIA, JANUARY 15 - MARCH 13, 2002

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ABSTRACT

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Dives were conducted at Snake Island in the Strait of Georgia between January 15-March 13, 2002 in order to provide lingcod (*Ophiodon elongatus*) egg mass density estimates. Exploratory dives were conducted on January 15, 2002 and a few egg masses and several males were observed at this time. To estimate egg mass density, 27 dives were completed on 8 days between February 1-March 13, 2002. A dive conducted on March 13, 2002 at a location where egg masses had been marked on February 1, 2002 revealed that many of the egg masses were hatched out and greatly reduced in volume, indicating the near end of the nesting season. In total, 50 egg masses were located within a total area of 8478 m^2 with density estimates per quadrat ranging from 0.0000-0.0255 egg masses/m^2, a median egg mass density of 0.0032 egg masses/m^2 and a mean egg mass density of 0.0059 egg masses/m^2. This is very close to the egg mass densities observed in 2001. There were 42 males observed guarding 47 egg masses, leaving 4 egg masses unguarded. Males ranged in total length from 54 cm to 80 cm with a mean length of 64.4 cm.

RÉSUMÉ

King, J. R., and P. M. Winchell. 2002. Lingcod (*Ophiodon elongatus*) egg mass density SCUBA survey in the Strait of Georgia, January 15-March 13, 2002. Can. Tech. Rep. Fish. Aquat. Sci. 2437: 16 p.

Nous avons réalisé entre le 15 janvier et le 13 mars 2002 des relevés en plongée à l'île Snake, dans le détroit de Georgia, en vue d'estimer la densité des masses d'œufs de morue-lingue (*Ophiodon elongatus*). Des plongées exploratoires ont eu lieu le 15 janvier 2002, et quelques masses d'œufs et plusieurs mâles ont été observés à ce moment-là. Pour estimer la densité des masses d'œufs, nous avons effectué 27 plongées au cours de huit journées entre le 1er février et le 13 mars 2002. Une plongée réalisée le 13 mars 2002 à un endroit où des masses d'œufs avaient été marquées le 1er février a révélé que les œufs avaient éclos et que les masses avaient un volume nettement réduit, ce qui indiquait la fin de la saison de nidification. Au total, 50 masses d'œufs ont été localisées dans une zone d'une superficie totale de 8 478 m^2, l'estimation de la densité par quadrat allant de 0,0000 à 0,0255 masses d'oeufs/m^2, ce qui correspond à une densité médiane de 0,0032 masses d'oeufs/m^2 et à une densité moyenne de 0,0059 masses d'œufs/m^2. Nous sommes là très près des densités observées en 2001. Nous avons relevé la présence de 42 mâles gardant 47 masses d'œufs, de sorte que 4 masses d'œufs n'étaient pas gardées. Les mâles présentaient une longueur totale de 54 cm à 80 cm, avec une longueur moyenne de 64,4 cm.

INTRODUCTION

Lingcod (*Ophiodon elongatus*) have traditionally been a very important species in British Columbia's commercial fishery. Since the closure of the commercial fishery for lingcod in the Strait of Georgia in 1990, the main source of abundance information has come from annual creel surveys and intermittent egg mass density SCUBA surveys. Egg mass density surveys were conducted in 1978, 1990, 1991, 1994 and 2001 (Low and Beamish, 1978; Yamanaka and Richards, 1995; King and Beaith, 2001). Dodd Narrows (Figure 1) was the site of the first lingcod egg mass density survey in 1978 (Low and Beamish 1978). In 1990, Dodd Narrows was re-visited and no lingcod egg masses were found so an alternate survey site, the reef at Snake Island (Figure 1), was selected for the study (Yamanaka and Richards, 1995). Subsequent egg mass density surveys were completed in 1991 and in 1994 on the Snake Island reef (Yamanaka and Richards, 1995). In January and February 2001, exploratory dives were conducted throughout Dodd Narrows where only 3 egg masses were observed, and at Snake Island where several egg masses were observed during a single dive (January 16, 2001) on a small portion of the reef. Dodd Narrows was not selected as an index site and the Snake Island site was quantitatively surveyed in 2001 (King and Beaith, 2001). The Snake Island survey was repeated in 2002 and is reported here. By following the same protocol, a time series of egg mass abundance can be established for Snake Island reef which will be useful in assessing and monitoring the abundance of spawning lingcod in the Strait of Georgia. The egg mass densities observed at this index site augment other sources of data on lingcod abundance and provide insight into relative abundance trends.

METHODS

The Snake Island reef was divided into 8 sections (Figures 2). King and Beaith (2001) suggested that there were areas on the reef that appeared to be preferred habitat for spawning and that survey effort should focus on those areas. However, for 2002 it was decided that additional information on habitat, particularly percent coverage of *Agarum spp.*, would be useful for classifying preferred spawning habitat. Additionally, surveys in 1990, 1991 and 1994 did not record exact locations of quadrats and comparisons of egg mass density estimates based on preferred habitat survey to previous surveys would be difficult. For each dive, a section was randomly selected but a cycle of sections 1-8 was completed before a section could be selected again. Sections were randomly selected within a cycle since budgetary constraints meant that the survey could be terminated on short notice and a cycle might not be completed or it was unknown how frequently dives could be conducted. A surface deployed anchor buoy was released according to both a GPS position and a diveable depth (<60 ft.) on the reef. Attempts were made to ensure even coverage within a section, and to avoid locations that had already been surveyed. Two divers descended from the marker buoy to the cannonball and then attached a 10 m line to the cannonball which is the fixed base of the marker buoy. The team of two divers would then swim a circle, with a radius of 10 m formed by the sweeping line, around the fixed point searching for egg masses. Upon the discovery of an egg mass the following information was recorded: the depth (ft) at which the egg mass was located; location of the egg mass (uncovered, beneath overhanging rocks, within a horizontal or vertical crevice); presence of a guarding male and its total length (cm); and the stage of egg development. Egg development stages were described by colour and were classified as creamy (new), white (intermediate), grey-white (old), eyed eggs (almost hatched), and hatched. Underwater dive lights were used to aid in the accurate assessment of the eggs' developmental stages. The total length of the guarding male was estimated using measuring tape pulled alongside the resting male. At the end of each dive, the depth of the cannonball (ft), visibility (m), and the number of lingcod not guarding a nest in the quadrat were recorded. Depths were measured in feet with the divers' depth gauges and were later converted to depth in meters. However, they were not converted to below chart datum since the depth at observation best reflects the spawning habitat used by lingcod during the winter. The slope of the quadrat was estimated (flat, gradual or steep). The habitat was described using four categories: rocky, barren, cobble, boulders. The top three categories were ranked by order of proportion to best describe the habitat, with the dominant habitat feature being ranked higher than secondary and tertiary features. The type of flora that existed in each quadrat was noted as *Agarum spp* or encrusting. In quadrats containing *Agarum spp*, the divers made an estimate of percent cover over the quadrat. A conscious effort was made to lift flora in search of hidden egg masses.

In previous surveys, egg mass volume was visually estimated to the nearest 0.5 L, with reference to a known 2 L volume. King and Beaith (2001) recommended that the dimensions of an egg mass be measured and used to estimate volume since visual estimates of volume were dubious. In 2002, volumes of egg masses were estimated from the measured dimensions of the egg mass (length, width and height to the nearest cm). Egg mass volumes were occasionally estimated visually to the nearest 0.5 L prior to the egg mass size measurements being taken. This was used to compare the 2001 data on egg mass volumes and the validity of the visual estimation technique. The same diver was used in 2002 as in the 2001 survey to consistently estimate egg mass volume.

Depending on the weather, 1-6 quadrats were completed each day. Sampling began February 1, 2002, ended March 13, 2002, and occurred between the hours of 9:00 and 14:00 PST. It was intended to dive at least once a week during the sampling period, with the most intense sampling taking place from mid-February to mid-March during the peak nesting period with 3-4 dives per week. Other commitments occasionally made this unattainable, but all efforts were made to maintain a solid time-series for the sampling frequency during the survey. The egg masses in quadrat 1 were visited repeatedly between February 1 to 27, 2002 for a separate genetic study. This allowed for a relative measure of egg mass development throughout the season.

RESULTS

EGG MASS DENSITY

Twenty-seven quadrat counts were completed over 8 days during February 1 to March 13, 2002 (Table 1). In 2002, the number of random visits to each of the 8 survey sections was approximately equal (Table 1), but less numerous than the 2001 survey (King and Beaith, 2001). Fifty egg masses were located within a total surveyed area of 8478 m^2 with an overall median egg mass density of 0.0032 egg masses/m^2, a range of 0.0000-0.0255 egg masses/m^2, and a mean estimate of 0.0059 egg masses/m^2. The 2002 median and mean density estimates are within the range of estimates from previous surveys conducted at Snake Island (Table 2). There were differences in median egg mass density estimates between survey years (Kruskal-Wallis one-way ANOVA test statistic=18.43, p=0.001). Comparison of mean ranks using varying critical z-values based on varying sample sizes, determined that 1994 and 2001 were significantly higher than 1991. This reflects higher maximum egg mass densities and upper quartiles observed in those two years (Figure 3).

EGG MASS OBSERVATIONS

During exploratory dives in mid-January, male lingcod were observed to be territorial. Egg masses began to appear on the reef in mid-January and lasted until mid March with a peak spawning period, based on egg development colour, in February (Table 3). The last date in which a newly laid egg mass (egg colour = creamy white) was found was March 13, 2002 (Table 3). However, it is likely that this egg mass was not viable since algae was noted to be growing on its surface. Forty-two males were observed guarding 47 egg masses, with an additional 4 unguarded egg masses. Of the 50 egg masses found, 92% of all observed egg masses were guarded, and of those guarded egg masses, 9.5% of males were guarding multiple egg masses (Table 3). Eighty-two percent of discovered egg masses were beneath overhanging rocks, 12% were within a horizontal crevice, 4% in a vertical crevice and 2% of egg masses were in the open (Table 3).

SITE AFFINITY

During the 2001 dive survey on the Snake Island reef, nests were individually marked using galvanised spikes and flagging tape with the nest number written on it (King and Beaith 2001). During the 2002 survey of the Snake Island reef, 6 nests were situated in the same location as a marker from the previous year's survey. Only 2 of the 6 flagging tape tags could be read with absolute certainty (nests #86 and 90), one tag was uncertain (either #62 or 67). The other 3 markers did not have enough flagging tape remaining to retain the nest label.

HABITAT

The habitat found at Snake Island reef varies with depth. The upper 10 m of the reef is composed mainly of flat sandstone with very little percent coverage (33%) of *Agarum spp.* There are some rocky areas, with small boulders (<1 m diameter), and sandstone outcroppings. As depth increases (>10 m) the bottom becomes more rugged, with an increase in boulder size (>1 m diameter) and percent coverage (70%) of *Agarum spp.* There is an increase in bottom slope with depth for most areas of the reef, particularly on the west side. Good visibility in the water column exists before the plankton bloom in the Strait of Georgia commences.

The shallowest part of the reef was found in section 3. Sections 2, 6 and 8 were deeper than 3, 4 and 5 (Figure 2), contained uneven rocky substrate, and had higher concentrations of algae, primarily (*Agarum spp.*) and decreased visibility (Table 1). Sections 1 and 7 were the deepest of the 8 sections (Figure 2), with the steepest substrate slope mixed with rocky and uneven terrain, a reduction in visibility and an increase in algal (*Agarum spp.*) presence. Quadrats with large egg mass counts (≥ 3) had generally less than 50% of percent coverage of *Agarum spp.* (Table 3).. Typically these quadrats had a high degree of ruggedness, or relief, to the bottom, with rocky or boulder habitat descriptions most common as the primary habitat classification. Generally, these habitat types were found primarily in reef sections 3, 4 and 5 (Figure 2). Though most of section 1 would not be characterised by these descriptions, the quadrats in section 1 with high number of egg mass counts did have this type of habitat (Table 1). Quadrats with no egg masses present generally had large percent coverage (≥ 70%) of *Agarum spp.* and were typically characterised as having a low degree of ruggedness, with barren or cobble (i.e. small rocks) as the most common primary habitat classifications. It is important to note that *Agarum spp.* leaves were lifted when searching for egg masses and the small number of egg masses located in quadrats with a high percent coverage of *Agarum spp.* is not likely due to undiscovered egg masses. Slope did not appear to be associated with either high or low egg mass densities.

VOLUME ESTIMATES

The visual estimate of egg mass volume appeared to be inadequate. On average, the calculated volumes from measurements were 3 times larger than visual estimates (Table 4). A possible factor could be that more time was taken by the diver to take measurements. In a visual estimate, the egg mass might be quickly scanned and part of the egg mass that was further under the rock may have been excluded from the volume estimate. This is evident in the comparison of the egg masses that were located in horizontal and vertical crevasses (easier to visually estimate) to those egg masses that were located under rocks. It also appears visual volume estimates of smaller egg masses were more accurate than visual volume estimates of larger egg masses.

GUARDING MALE LENGTH

Males ranged in length from 54 to 80 cm. The mean length of nest guarding males in 2002 was 65.2 cm (n=38) which corresponds to size at age 4. Lengths were collected in 1990 and 2001 (Figure 4). The mean length in 1990 was 62.9 (n=54), approximately age 3-4. In 2001, the mean length was 61.9 (n=74), approximately age 3-4. ANOVA indicates that the mean length in 2002 was significantly larger than 2001, but not 1990 (F=5.47, p=0.005).

EGG DEVELOPMENT

The egg masses in quadrat 1 (indicated by the star in section 3, Figure 2) were visited repeatedly between February 1-27, 2002 for a separate genetic study (Withler et al., 2003). This allowed for a relative measure of egg development throughout the season. On February 1, 2002, the first date these egg masses were observed, the dominant egg colour code was 1 or 2; indicating newly spawned eggs. On February 13, 2002, the approximate middle of the genetic sampling work, egg masses showed a variety of maturity levels. These ranged from white to eyed. The first observation of eyed eggs was on February 6. On March 13, the last day of the survey, all egg masses were almost entirely hatched out, and greatly reduced in size. Many of the males remained associated with the nest site, even though the egg mass was gone. Throughout the field season, egg masses were removed for the genetic study and some egg masses disappeared, presumably due to predation. It should be noted that males were observed to be closely associated with the vacant nest site for several weeks.

MISCELLANEOUS OBSERVATIONS

There were observations made during the 2002 survey that are interesting and should be noted. There were some instances of extreme aggressive behaviour displayed by guarding males, such as a large individual (79 cm) that was guarding 3 egg masses in quadrat 1. This behaviour included biting of divers, chasing divers and providing bodily defence of the egg masses. Another guarding male was seen to remove a seastar predator from a nest, carry it and release it approximately 2 meters away. One individual had a large wound (approximately 15 cm long, 3 cm wide and 2-4 cm deep) on its side, with internal organs visible. This male was still around and active for another month of the dive survey. There were also a few occurrences of sea lice (*Copepodia spp.*) on the heads of some of the nest guarding males, up to a density of approximately 10 per individual.

DISCUSSION

This is the fifth year that a lingcod egg mass density survey has been conducted at the Snake Island reef index site. Based on the overall distribution of quadrat densities observed in each survey year, there has not been a dramatic or sustained increase in egg mass densities since 1990. It important to note that a dive survey has a limited application to providing an index for relative abundance. Lingcod are a non-migratory species, that likely remain associated with a particular reef throughout the spawning portion of its lifetime. The use of several reefs in an area would be required to infer large-scale abundance dynamics.

It is also important to note that the nesting survey design has varied each year. In 1990, nest density estimates were calculated using 50-60 m transects, arbitrarily placed on the reef, with divers searching 7 m on opposite sides of the transect line (Yamanaka and Richards, 1995). It was not described how transect locations on the reef were selected. In 1991 circular quadrats (10 m radius) were arbitrarily placed on the reef using the anchor as the first base point (Yamanaka and Richards, 1995). The quadrat was searched and upon completion divers would then swim at least 20 m away in any direction and arbitrarily select another base point for the following quadrat. In 1994, surface-deployed anchor buoys were used to mark locations on the reef which were used as the base points for circular quadrats with a 10 m radius (Yamanaka and Richards, 1995). Again, for 1991 and 1994 it is not described how the starting locations on the reef were selected. For 1990, 1991 and 1994 surveys, locations of transects or quadrats on the reef were not recorded. These variances in survey designs makes direct comparision of density estimates between years difficult, especially since there appears to be a preferred area of the Snake Island reef for spawning sites.

Lengths collected in 1990, 2001 and 2002 suggests that, while 2002 males were larger than 2001 males, the increase is not dramatic. There is no significant difference in lengths of guarding males measured in 2002 and 1990. In 2001 the mean length corresponds to an age of 3-4. In 2002, the approximate age is 4-5 which suggests that the 1996 and 1997 cohorts are dominating the male spawning population at Snake Island.

There was a noticeable difference in the egg mass densities found among each of the individual sections on the reef. Sections 3, 4 and 5 contained more egg masses and larger nest guarding males than the remaining sections. These areas of preferred spawning habitat are generally flat or with a gradual slope, with a lot of barren space, rocks and some boulders and very little sandy substrate or percent coverage by large flora (e.g. *Agarum*). The habitat of these quadrat areas suggest that lingcod require, along with rocky crevices for egg deposition, open spaces with improved visibility for spawning behaviour or for effective nest guarding. Open spaces may also provide sufficient current flow for egg development.

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Table 1. Data for Snake Island reef quadrats including date sampled, section area (see Figure 2), the latitude and longitude (in degrees, minutes, seconds) of the buoy marker, quadrat depth (m) as measured by depth gauge at the buoy line, visibility (m) in the water column, the number of egg masses observed, the number of observed egg masses with guarding males, and the number of males observed in the quadrat that were not guarding a nest. The slope (flat, gradual and steep) of the quadrat was estimated for the majority of the quadrat. The approximate percent of *Agarum spp* cover, and the top three habitat descriptions for each quadrat is included.

Date	Quadrat number	Section	Latitude	Longitude	Quadrat depth (m)	Visibility (m)	Number of egg masses	Number of guarded egg masses	Number of non-guarding males observed	Slope	% Agarum	Habitat classifications		
												Primary	Secondary	Tertiary
01-Feb-02	1	3	491243.70	1235304.70	8.5	12	7	7	0	Flat	0	Rocky	Boulders	Barren
13-Feb-02	2	4	491240.90	1235303.50	9.4	12	2	2	1	Gradual	30	Barren	Rocky	
13-Feb-02	3	5	491240.80	1235306.90	6.7	12	2	2	2	Flat	0	Barren	Rocky	Boulders
13-Feb-02	4	7	491237.30	1235307.60	8.5	10	2	2	2	Steep	50	Barren	Boulders	Rocky
15-Feb-02	5	6	491237.80	1235305.50	8.2	11	0	0	1	Gradual	0	Barren	Rocky	
15-Feb-02	6	1	491245.50	1235302.80	12.2	10	2	1	0	Steep	90	Rocky	Boulders	Cobble
15-Feb-02	7	8	491234.60	1235306.80	8.5	10	2	2	1	Flat	90	Boulders	Rocky	
15-Feb-02	8	2	491242.40	1235302.40	11.3	10	1	1	2	Flat	75	Boulders		
15-Feb-02	9	3	491243.40	1235306.90	10.1	10	2	2	2	Gradual	70	Rocky	Barren	
20-Feb-02	10	5	491240.50	1235307.00	7.9	15	6	5	2	Steep	30	Barren	Rocky	Boulders
20-Feb-02	11	4	491240.50	1235304.70	10.1	11	2	2	0	Steep	30	Barren		
22-Feb-02	12	4	491239.50	1235304.20	12.2	15	0	0	2	Flat	70	Barren	Boulders	Rocky
22-Feb-02	13	2	491244.50	1235302.50	9.4	12	0	0	1	Flat	10	Barren		
25-Feb-02	14	7	491238.50	1235307.10	9.1	10	3	3	0	Flat	70	Rocky	Cobble	
25-Feb-02	15	8	491235.50	1235306.70	8.5	10	0	0	1	Flat	80	Cobble		
25-Feb-02	16	6	491238.90	1235304.00	11.3	9	0	0	1	Gradual	80	Rocky	Barren	
25-Feb-02	17	1	491246.80	1235305.00	12.8	9	3	3	1	Steep	90	Boulders	Rocky	
25-Feb-02	18	3	491242.10	1235306.40	10.7	9	0	0	0	Steep	40	Cobble	Barren	Boulders
01-Mar-02	19	5	491239.70	1235307.00	7.6	9	1	1	3	Flat	0	Barren/Rocky	Cobble	
01-Mar-02	20	1	491246.20	1235307.50	12.2	9	3	3	2	Steep	50	Rocky	Barren	
01-Mar-02	21	2	491245.00	1235303.60	6.4	11	1	1	2	Flat	5	Barren		
01-Mar-02	22	3	491244.70	1235304.90	6.7	9	1	1	1	Flat	20	Rocky	Barren	Boulders
01-Mar-02	23	6	491236.10	1235304.80	9.1	15	1	1	1	Gradual	80	Barren	Boulders	
01-Mar-02	24	4	491239.20	1235306.10	5.8	15	8	7	0	Gradual	0	Barren	Boulders	
13-Mar-02	25	8	491234.00	1235308.00	12.5	12	0	0	2	Steep	95	Rocky	Boulders	Barren
13-Mar-02	26	7	491238.00	1235309.00	11.3	12	0	0	0	Steep	80	Barren	Rocky	
13-Mar-02	27	5	491239.00	1235308.00	8.8	12	1	1	3	Gradual	70	Barren	Rocky/Boulders	

Table 2. Summary of egg mass densities (egg masses/m^2) estimated from the 5 egg mass density surveys, conducted at Snake Island.

Survey Year	Time Period	Number of egg masses	Number of quadrat / transect counts	Density Estimates	
				Median	Mean
1990	Feb16-Mar 16	104	37	0.004286	0.003745
1991	Mar 18-Mar 21	14	22	0.003185	0.002027
1994	Feb 10-Mar 15	78	29	0.006369	0.008456
2001	Jan 16-Apr 26	107	74	0.003185	0.005853
2002	Feb 1-Mar 13	50	27	0.003185	0.005898

Table 3. Data for each egg mass observed. Note that numbers 7, 9-18 are not used here. The quadrat and section that each egg mass was observed in is noted. The depth (m) of the egg mass location, the egg mass dimensions (length, width and height to the nearest cm) and volume (cubic cm) along with the location of the egg mass, the colour of the eggs, the presence of a male guarding one egg mass (M1), guarding two or three egg masses in sequential order (M2 or M3) or an unguarded egg mass (M0), and the total length (cm) of the guarding male are included. The egg mass location codes include: out in the open=0; under rock=1; in horizontal crevice=2; in vertical crevice=3. Egg development is coded by the following: 1=creamy white (new); 2=white (intermediate); 3=grey white (old); 4=eyed eggs (nearly hatched); 5=hatched. If a male was present, but no length is indicated, then measurement was not possible.

Date	Egg mass number	Quadrat number	Section number	Egg mass depth (m)	Egg mass location	Egg colour	Length (cm)	Width (cm)	Height (cm)	Volume (cm^3)	Male present	Length of male (cm)
01-Feb-02	1	1	3	8.8	1	1/2	38	10	15	5700	M3	79
01-Feb-02	2	1	3	8.8	1	1/2	18	28	10	5040	M3	79
01-Feb-02	3	1	3	8.8	1	1/2	25	9	25	5625	M3	79
01-Feb-02	4	1	3	8.8	1	1/2	31	17	10	5270	M1	58
01-Feb-02	5	1	3	8.8	1	2	19	19	8	2888	M1	67
01-Feb-02	6	1	3	8.2	1	2	35	10	15	5250	M1	71
01-Feb-02	8	1	3	8.5	1	2	25	20	8	4000	M1	69
13-Feb-02	19	2	4	8.8	1	2/3/4	17	8	18	2448	M1	61
13-Feb-02	20	2	4	10.4	1	1	25	12	14	4200	M1	
13-Feb-02	21	3	5	5.2	1	2	42	12	12	6048	M1	
13-Feb-02	22	3	5	6.7	1	1	20	9	8	1440	M1	56
13-Feb-02	23	4	7	7.9	2	2/3	20	20	8	3200	M1	60
13-Feb-02	24	4	7	7.6	1	1	40	20	12	9600	M1	65
15-Feb-02	25	6	1	12.5	1	2	23	26	9	5382	M1	60
15-Feb-02	26	6	1	13.7	1	1/2	27	21	9	5103	M0	
15-Feb-02	27	7	8	8.8	1	2/3	37	24	9	7992	M1	54
15-Feb-02	28	7	8	8.8	1	3	30	12	13	4680	M1	80
15-Feb-02	29	8	2	11.9	1	2	30	15	13	5850	M1	73
15-Feb-02	30	9	3	9.4	1	3	26	26	14	9464	M1	62
15-Feb-02	31	9	3	9.4	1	2	22	10	12	2640	M1	58
20-Feb-02	32	10	5	9.1	1	2	18	13	10	2340	M1	63
20-Feb-02	33	10	5	7.6	1	3/4	24	12	13	3744	M1	67

Date	Egg mass number	Quadrat number	Section number	Egg mass depth (m)	Egg mass location	Egg colour	Length (cm)	Width (cm)	Height (cm)	Volume (cm^3)	Male present	Length of Male (cm)
20-Feb-02	34*	10	5	6.7	1	2					M3	72
20-Feb-02	34b*	10	5	6.7	1						M3	72
20-Feb-02	34c*	10	5	6.7	1						M3	72
20-Feb-02	35	10	5	6.7	2	3/4	25	9	12	2700	M0	
20-Feb-02	36	11	4	7.6	1	3/4/5	26	18	10	4680	M1	71
20-Feb-02	37	11	4	10.7	1	3/4/5	41	12	13	6396	M1	61
25-Feb-02	38	14	7	8.8	1	3/5	23	7	26	4186	M1	77
25-Feb-02	39	14	7	9.4	1	3/4/5	32	14	15	6720	M1	68
25-Feb-02	40	14	7	9.1	2	3/4/5	12	38	32	14592	M1	58
25-Feb-02	41	17	1	12.5	1	3/4	30	13	13	5070	M1	67
25-Feb-02	42	17	1	11.0	1	2	20	11	12	2640	M1	67
25-Feb-02	43	17	1	13.7	2	3/4	25	12	5	1500	M1	
01-Mar-02	44	19	5	7.0	1	3/4	15	24	11	3960	M1	65
01-Mar-02	45	19	5	7.6	0	3/4	13	10	6	780	M0	
01-Mar-02	46	20	1	12.2	1	3/4	49	21	8	8232	M1	68
01-Mar-02	47	20	1	11.9	1	3/4	19	15	11	3135	M1	68
01-Mar-02	48	20	1	13.7	1	3/4					M1	63
01-Mar-02	49	21	2	6.4	2	4	28	10	15	4200	M1	66
01-Mar-02	50	22	3	7.0	1	4	28	12	13	4368	M1	67
01-Mar-02	51	23	6	11.0	1	3/5	20	11	12	2640	M1	64
01-Mar-02	52	24	4	5.8	1	3/5	30	11	20	6600	M2	61
01-Mar-02	53	24	4	5.8	1	1	30	12	20	7200	M2	61
01-Mar-02	54	24	4	6.1	1	4/5	12	12	4	576	M1	66
01-Mar-02	55	24	4	6.1	1	3/4/5	16	12	21	4032	M1	68
01-Mar-02	56	24	4	6.1	1	3/4/5	16	14	27	6048	M1	64
01-Mar-02	57	24	4	6.1	1	3/4/5	17	15	25	6375	M0	
01-Mar-02	58	24	4	6.1	3	4/5	25	27	10	6750	M1	64
01-Mar-02	59	24	4	6.1	3	4/5	17	12	14	2856	M1	62
13-Mar-02	60	27	5	9.1	2	1	22	20	10	4400	M1	64

*There were 2 egg masses associated with egg mass 34. However they were too far under the boulder to make any observations.

Table 4. A comparison of the visual volume estimates (L) and actual measured volume (based on, length width and height to the nearest cm) of the same egg masses in 2002. Egg mass location is noted where 1=under rock, 2=horizontal crevice, 3=vertical crevice.

Egg mass location	Visual estimate of volume (L)	Length (cm)	Width (cm)	Height (cm)	Calculated volume (L)	Calculated/ estimated
1	1.5	38	10	15	5.7	3.8
1	2	18	28	10	5.0	2.5
1	1	25	9	25	5.6	5.6
1	1	31	17	10	5.3	5.3
1	1	19	19	8	2.9	2.9
1	2	35	10	15	5.3	2.6
1	1.5	25	20	8	4.0	2.7
3	0.5	14	6	10	0.8	1.7
1	2	17	10	20	3.4	1.7
1	1.5	18	13	13	3.0	2.0
1	0.5	10	10	10	1.0	2.0
3	2.5	7	22	13	2.0	0.8
1	2	23	8	7	1.3	0.6
2	2	20	13	8	2.1	1.0
2	2	30	10	13	3.9	2.0

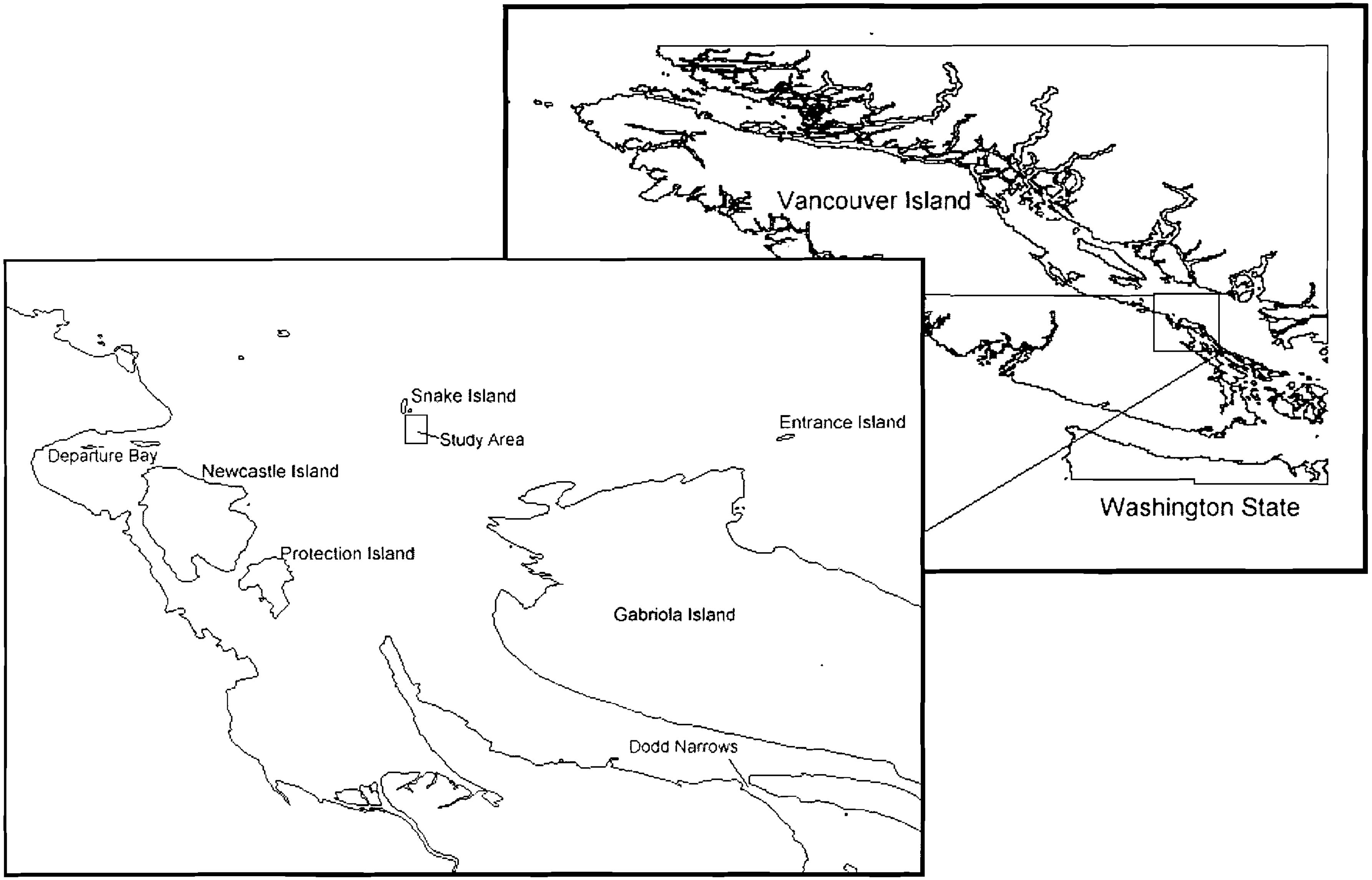

Fig.1. Location of area examined for lingcod egg masses. Inset shows the study area at Snake Island Reef.

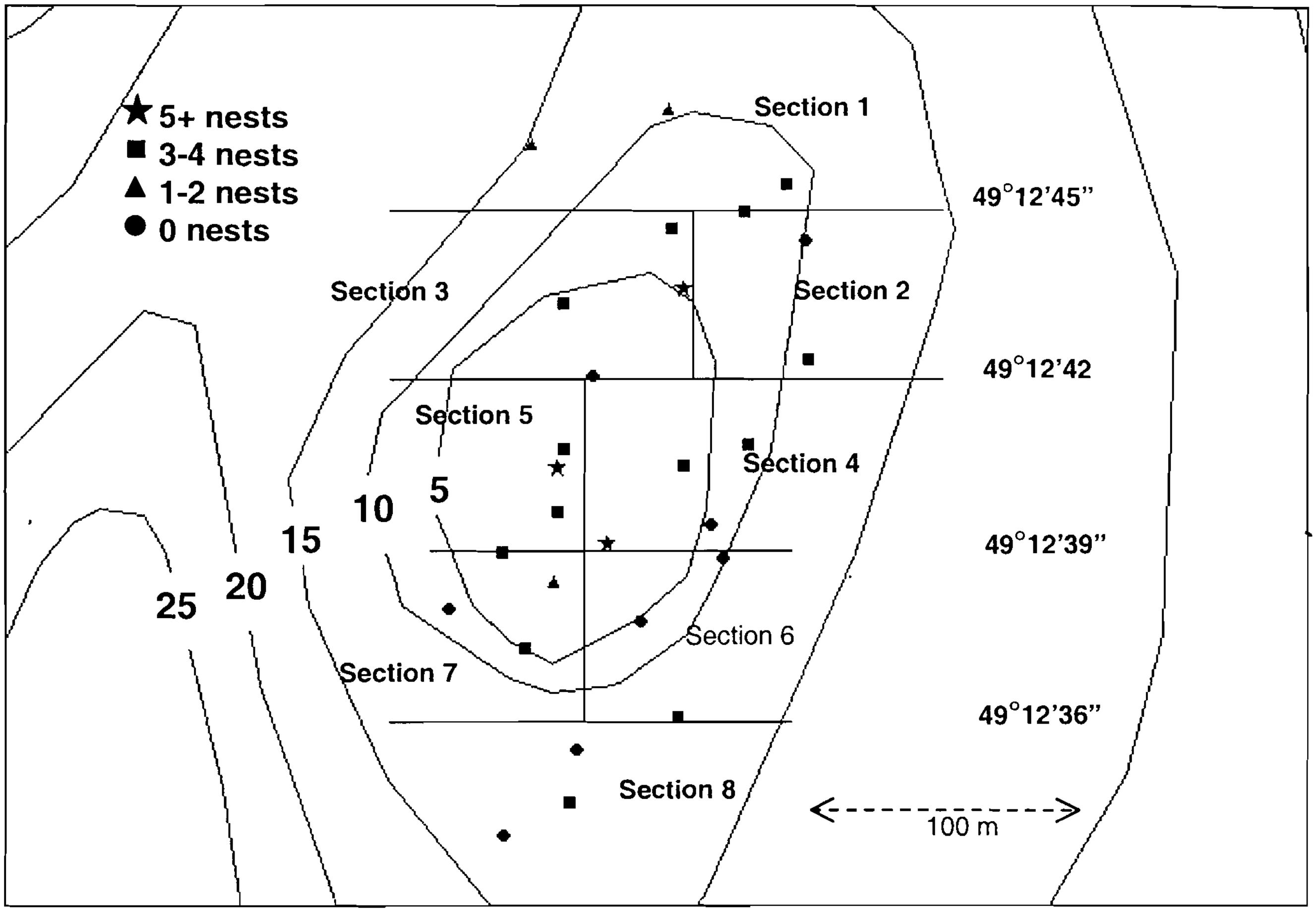

Fig. 2. Outline showing bathymetric contours (meters below chart datum) of Snake Island associated reef. The survey grid is placed over the reef with numbered sections. The longitude separating section 2 from 3 is 123°53'04.5", while sections 4 and 6 are separated from 5 and 7 respectively by 123°53'06.5". The approximate centre of the quadrat is given a symbol denoting the total number of egg masses found.

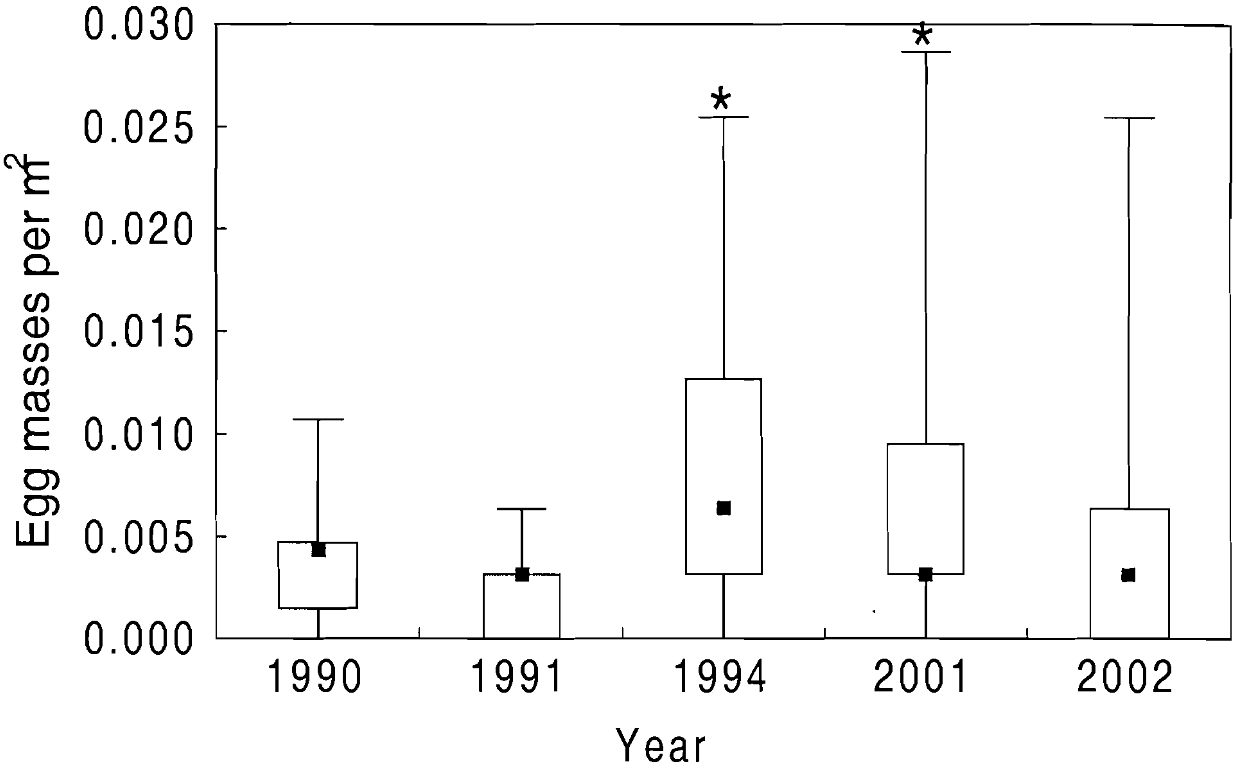

Fig. 3. Median egg mass density estimates for each survey year at Snake Island reef. Whiskers denote maximum and minimum egg mass densities observed, boxes denote 25 and 75 percentiles. Kruskal-Wallis ANOVA and comparison of mean ranks established that 1994 and 2001 median egg mass density estimates were significantly higher than 1991. Other years were not significantly different.

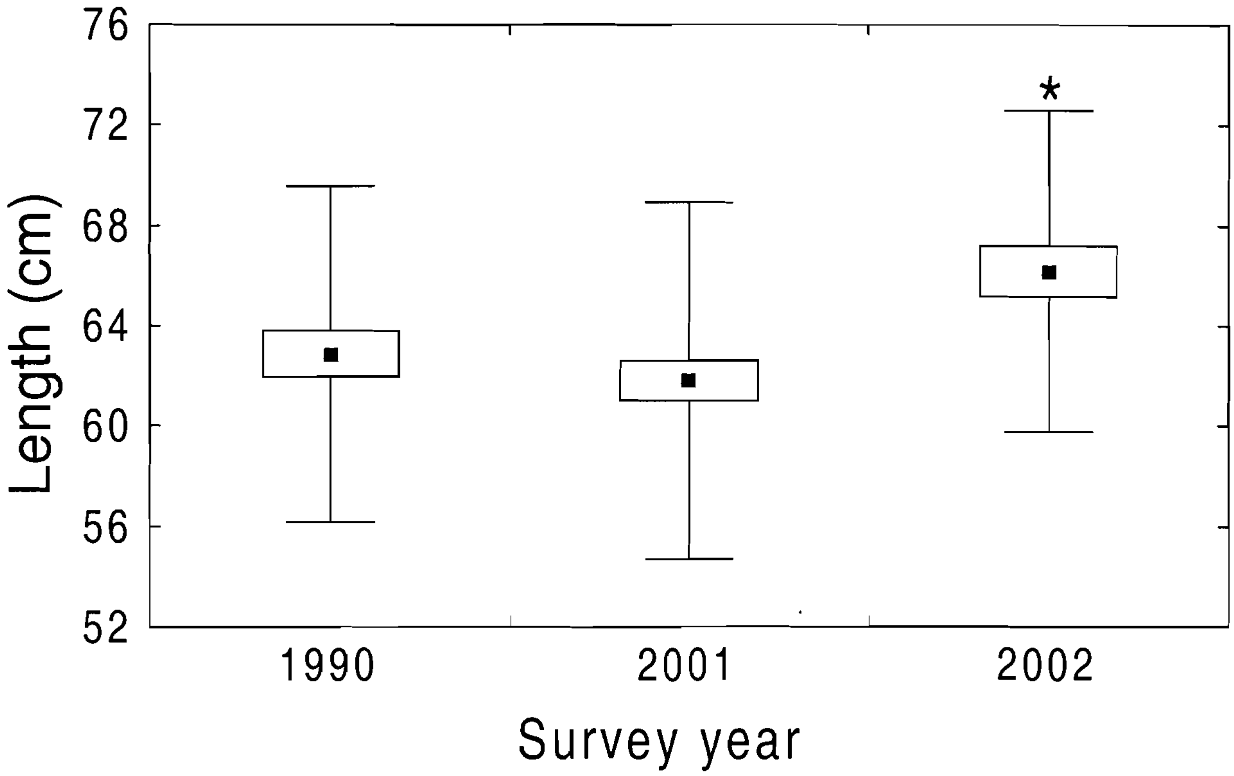

Fig. 4. Mean lengths (cm) of guarding males in 1990, 2001 and 2002. Boxes denote standard error, whiskers denote standard deviation. ANOVA results determined that the mean length in 2002 was significantly higher than in 2001, but not 1990.